



# **Orion Pad Abort 1 Flight Test**

## **Ground and Flight Operations**

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***The Operations Team with the  
PA-1 Test Vehicle***



## ***Presentation Overview***

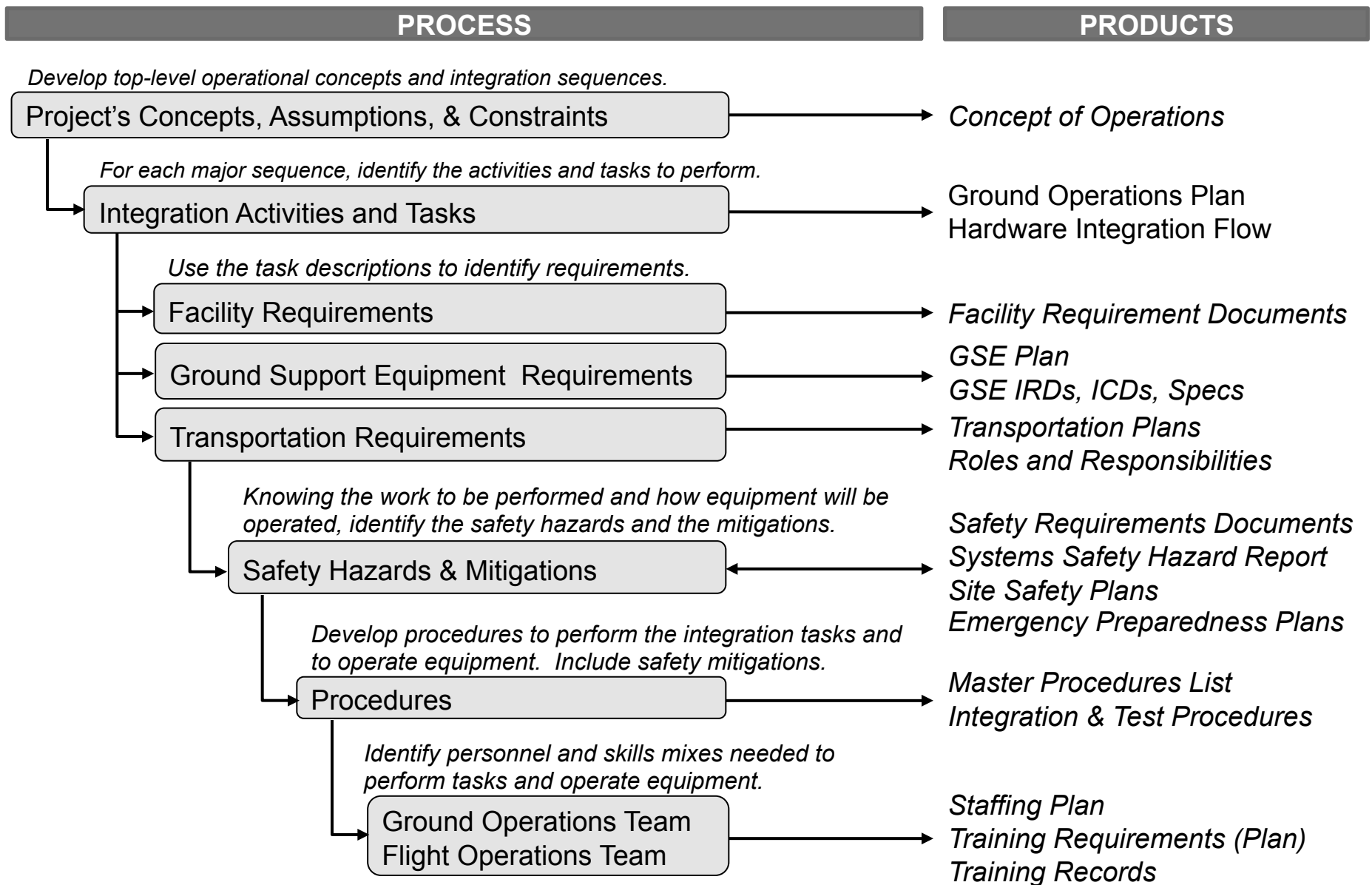
- Operational Planning
- Facilities Preparation
- Integration and Testing
- Flight Ops
- Other Challenges and Successes



# ***OPERATIONAL PLANNING***



# Approach to Operational Planning





## ***Project's overarching concepts, assumptions, & constraints drove the operational planning***

### Operations Group Responsibilities

- Plan for six flight tests:
  - Two (2) Pad Abort tests
  - Four (4) Ascent Abort tests
- Prepare the Test Vehicles
- Build the Launch Facilities
- Provide Mission Architecture to control test vehicle and to capture vehicle performance and aerodynamic data
- Perform the flight tests

### Mandates

- Meet ambitious launch schedule
- Protect for late installation of long lead time and life-limited items
- Use aggressive test and verification approach

### Considerations drove the Ground Operations planning

- Integrate the Test Vehicle in 2 phases to reduce time spent at launch site
- For PA-1:
  - Perform non-hazardous Crew Module integration at NASA Dryden Flight Research Center
  - Assemble Launch Abort System at Launch Site
  - Perform final hazardous processing at Launch Site

### Considerations drove the Mission Operations Architecture

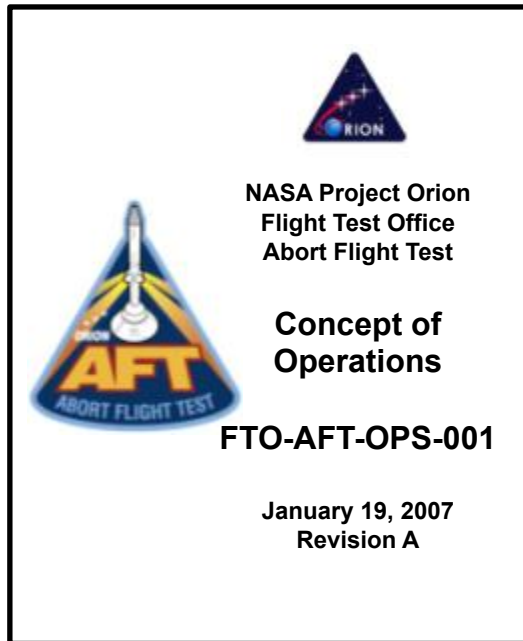
- Perform flight tests on an equipped test range
- Test range large enough to contain flight trajectories
- Use Mobile Launch Concept

### Considerations drove the Launch Facilities

- Support both Pad Abort and Ascent Abort tests
- Provide integration areas for Launch Abort System, Crew Module, and Abort Test Booster.
- Launch Complex sited for hazardous ordnance processing and explosives operations



# ***Concept of Operations Document established top level vehicle, ground, and flight operations concepts***



## Contents

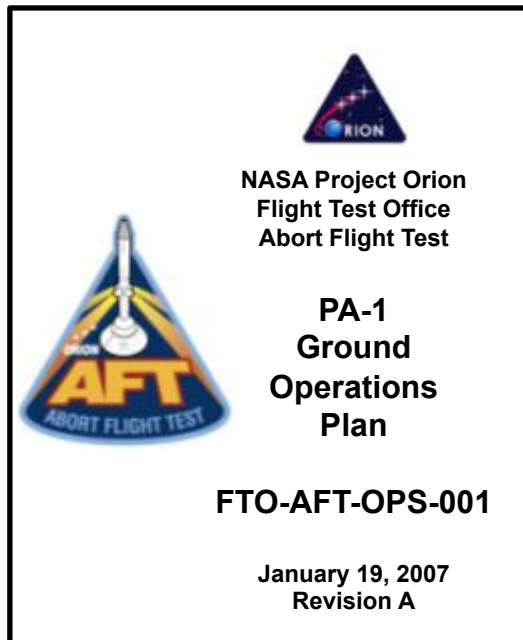
1. Organizational Roles and Responsibilities
2. Goals and Objectives
3. Abort Flight Test Scenarios
4. Test Vehicle Concepts
5. Ground Operations and Integration Flows
6. Flight Operations
7. Flight Operations for Ares Launch Opportunity
8. Training

## Purpose

- Identifies organizational roles and responsibilities
- Describes the Test Vehicle, its components and the component functions, and the component providers.
- Described the top-level integrations flows and the integration locations.
- Describes the mission architecture and the roles for conducting the flight operations.
- Conveys top-level guidance from which to start developing requirements and specifications



## ***Ground Operations Plan provided the detailed integration flows, activities, and task descriptions***



### Contents (Abbreviated Listing)

1. Roles and Responsibilities
3. Approach to Development
4. Ground Planning Documentation
5. Facilities
6. Ground Support Equipment
7. Initial Integration at Dryden Flight Research Center
8. Final Integration at WSMR
9. Pad Operations at WSMR
10. Recovery and Disposition Activities after Flight Test

### Purpose

- Provides the detailed hardware integration flows.
- Assembly and integration tasks described in detail.
- Identifies personnel, facility, and equipment resources required to perform each task.
- Includes over 250 storyboards
- Task descriptions provide the starting point for developing procedures.



# Over 250 Storyboards like this one used pictures to convey the integration sequences

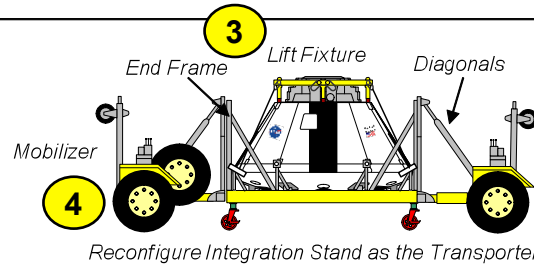
1

## 8.6.1 CM Mass Properties Test-- Weight Determination

### 1. Move CM to Test Location

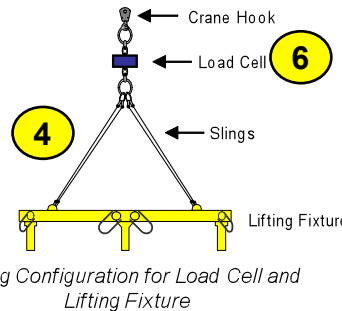
- ❑ Install CM vertical lifting fixture.
- ❑ Remove CM work stand.
- ❑ Configure CMTF for mobilizers.
- ❑ Move CM to test location

5



### 2. Set Up for Test

- ❑ Set up access control area.
- ❑ Configure test equipment.
- ❑ Prepare for critical lift operations.
- ❑ Roll in work stands.
- ❑ Configure load cell and lifting slings for lifting.
- ❑ Roll back work stands

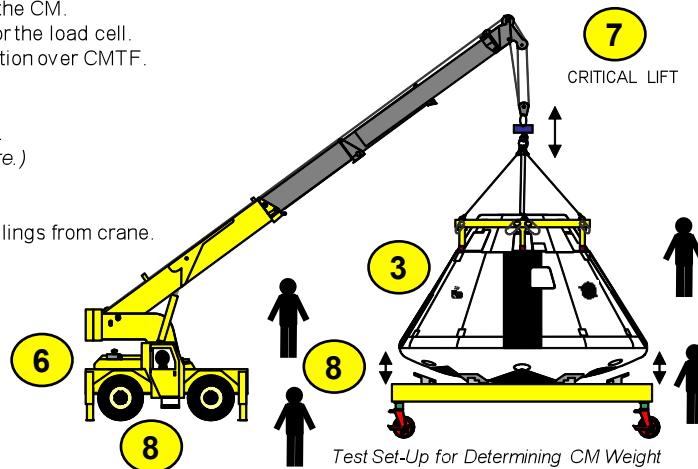


### 3. Conduct CM Weight Measurements

- ❑ Take up the slack in the slings and ensure the hook is centered over the CM.
  - ❑ Start the data logger for the load cell.
  - ❑ Lift CM into hover position over CMTF.
  - ❑ Record CM weight.
  - ❑ Stop data logger.
  - ❑ Lower CM onto CMTF.
- (Repeat per test procedure.)

(After last measurement):

- ❑ Unhook load cell and slings from crane.



1

Each operation linked to Integration Flow

2

Activity Sequence includes detailed task descriptions

3

Flight Hardware clearly shown  
• Crew Module (in this example)

4

Ground Support Equipment:  
• Crew Module Transporter  
• Crew Module Lift Fixture

5

Facility Resources can be identified:  
• Aircraft Integration Facility

6

Facility Equipment and placements:  
• Mobile Crane  
• Load Cell

7

Procedures  
• Convert Integration Stand to Transporter  
• Transport Crew Module  
• Critical Lift Pre-Task Planning  
• CM Weight Determination Procedure  
• "Critical Lift" involves hazardous ops

8

Personnel  
• Task Team Leader • Tug Operator  
• Safety Lead • Mobilizer Operators  
• QA Lead • Crane Operator  
• Lift Manager • Mechanics



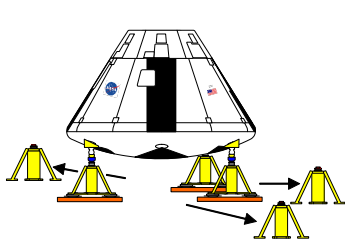


# Storyboards were good predictors of actual operations

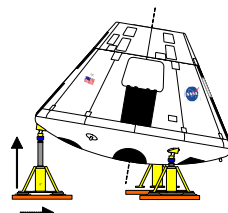
## Storyboard

### 8.6.2 CM Mass Properties Test – Center of Gravity Determination (page 2 of 3)

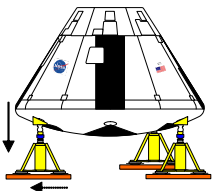
*For first measurement set:*



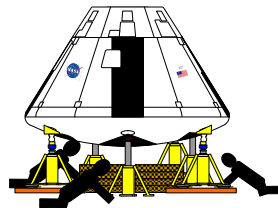
8. Retract and remove safety jacks.



9. Activate air bearing pallets; Start data loggers; Raise apex jack.



10. Record weights; Lower apex jack; stop data loggers.



11. After measurements sets are obtained, reset safety jacks under CM.

*Repeat Steps 9 and 10 as needed to obtain first measurement set.*

*For second measurement set:*

*Repeat Steps 8 through 11 using the 120-degree jack as the apex jack.*

*For third measurement set:*

*Repeat Steps 8 through 11 using the 240-degree jack as the apex jack.*

## Actual

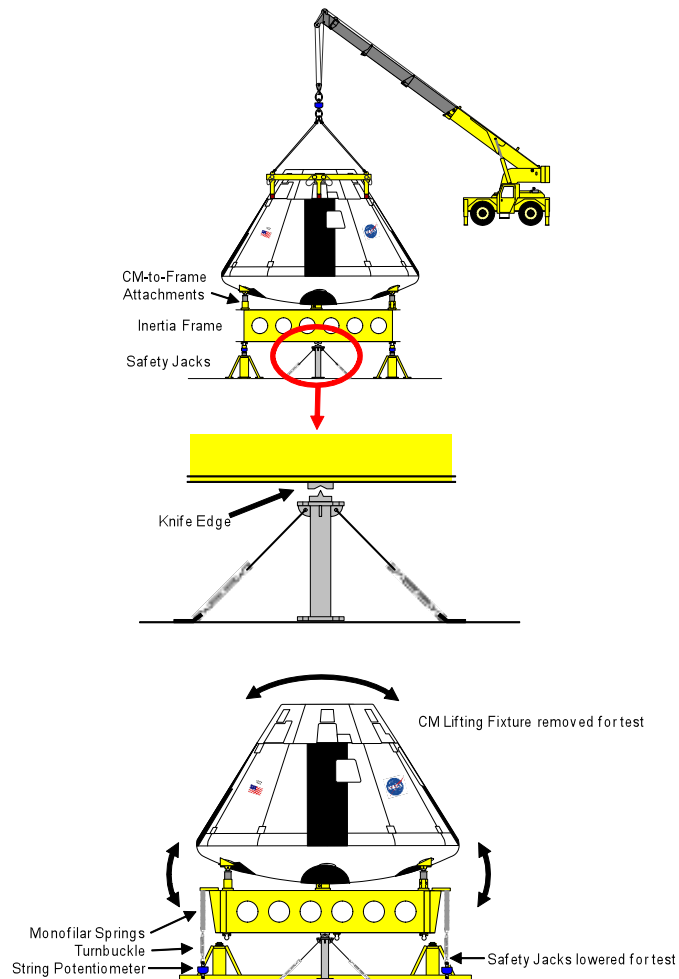




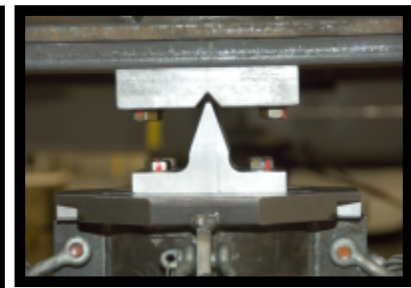
# Storyboard for the Crew Module Iyy Inertia Test

## Storyboard

### 8.7.4 CM Mass Properties Test – Iyy and Izz Inertia Determination



## Actual





# Swim Lanes were another tool used to plan resources, verifications, and prerequisites

DFRC Initial Integration					
8.2.4 CM Setup in Shuttle Hangar					
<div><div><div>SEQUENCES</div><div><div><div><div>April 1</div><div><p>Receive CM in Shuttle Hangar</p><ul style="list-style-type: none"><li><input type="checkbox"/> Position CM under overhead bridge crane</li><li><input type="checkbox"/> Orient CM to +Z North</li><li><input type="checkbox"/> Lower CM onto casters</li><li><input type="checkbox"/> Remove mobilizers</li><li><input type="checkbox"/> Establish grounds</li></ul></div><div><p>REQUIRES LIFT OPS</p><p>Convert CMTF into Integration Stand</p><ul style="list-style-type: none"><li><input type="checkbox"/> Prepare for Lift Operations</li><li><input type="checkbox"/> Remove CMTF end frames</li><li><input type="checkbox"/> Remove tie-downs</li><li><input type="checkbox"/> Remove tripods and tie-down hardpoints</li><li><input type="checkbox"/> Install lower work platform panels onto CM Integration Stand</li></ul></div><div><p>REQUIRES LIFT OPS</p><p>Prepare CM for CM Integration</p><ul style="list-style-type: none"><li><input type="checkbox"/> Remove CM hatch</li><li><input type="checkbox"/> Remove Panels #2 and #5</li><li><input type="checkbox"/> Remove #2 and #5 composite shoulder panels and aluminum supports</li><li><input type="checkbox"/> Rig interior lighting and utility power</li><li><input type="checkbox"/> Install CM temporary floor panels</li><li><input type="checkbox"/> Prepare for Lift Operations</li><li><input type="checkbox"/> Remove CM Lifting Fixture</li></ul></div></div><div><div>APR 4</div><div><p>CM Temporary Floor Panels</p><p>Removable Panel #6</p></div></div></div></div></div></div>					
PROCEDURES					
FTO-AFT-OPS-1004: DFRC FTA Local Transportation  Work Order: E15855 CM Grounding Reference: OMM CM Grounding Cable Assy PN# 948956030215 -501		Work Order: E15840 Removal of Panels 2&5, Tripods & Tie-Downs  FTO-AFT-OPS-1005: Installation and Removal of CMTF End Frames and Diagonals		Work Order: E15839 CM Hatch Removal Drawing: 1247018 Skin Assembly  Work Order E15840: Removal of Panels 2&5, Tripods & Tie-Downs Drawing: 1247018 Skin Assembly	
Tug (DFRC) Mobilizers (LaRC) Grounding Straps (LM)		Broderon Crane (DFRC) Lifting Straps Tag Lines Flat Bed Truck (transport goal posts to storage) B1 Work Stands Access Platforms		CM Lower Work Platform Panels	
GSE					
				B1 Work Stands Access Platform	
PERSONNEL					
DFRC tug operator DFRC Crew (Spotters) Mobilizer operators LaRC Representative		DFRC crane operator Ops Lead Crew Chief Crew (Optional) Safety Lead		DFRC crane operator Ops Lead Crew Chief Crew QA Lead (Optional) Safety Lead	
VERIFY					
		Crane – PM & equipment certification on file Lift Straps – Cert & Load tags		Load Test: CM Lower Work Platform Panels to 1,000 lbs (2 people) x 2 SF = 1,000 lbs	
PRE-REQS					
Shuttle Hangar prepped for arrival Tugs & Cranes – PM & Certs on file					

Page 1 of 1



# ***FACILITIES PREPARATION***



## ***Facilities Description***

- Facility Requirements Document (FRD) used to document launch complex requirements and to initiate design effort
- Construction of LC-32E facilities commenced on October 1, 2007
  - Final Integration and Test Facility (FITF)
  - Launch Pad
  - Launch Services Pad
  - Operations Support Trailer (OST)
- Construction of FITF complete in April 2008
- Construction of Launch Pad complete in August 2008







## ***PA-1 Vehicle on Launch Pad and FITF***



***Launch Pad and Gantry***



***Final Integration and Test Facility (FITF)***



***Integration Bays inside FITF***



***Aerial View of Orion Launch Complex 32 East***



***LC-32 East***



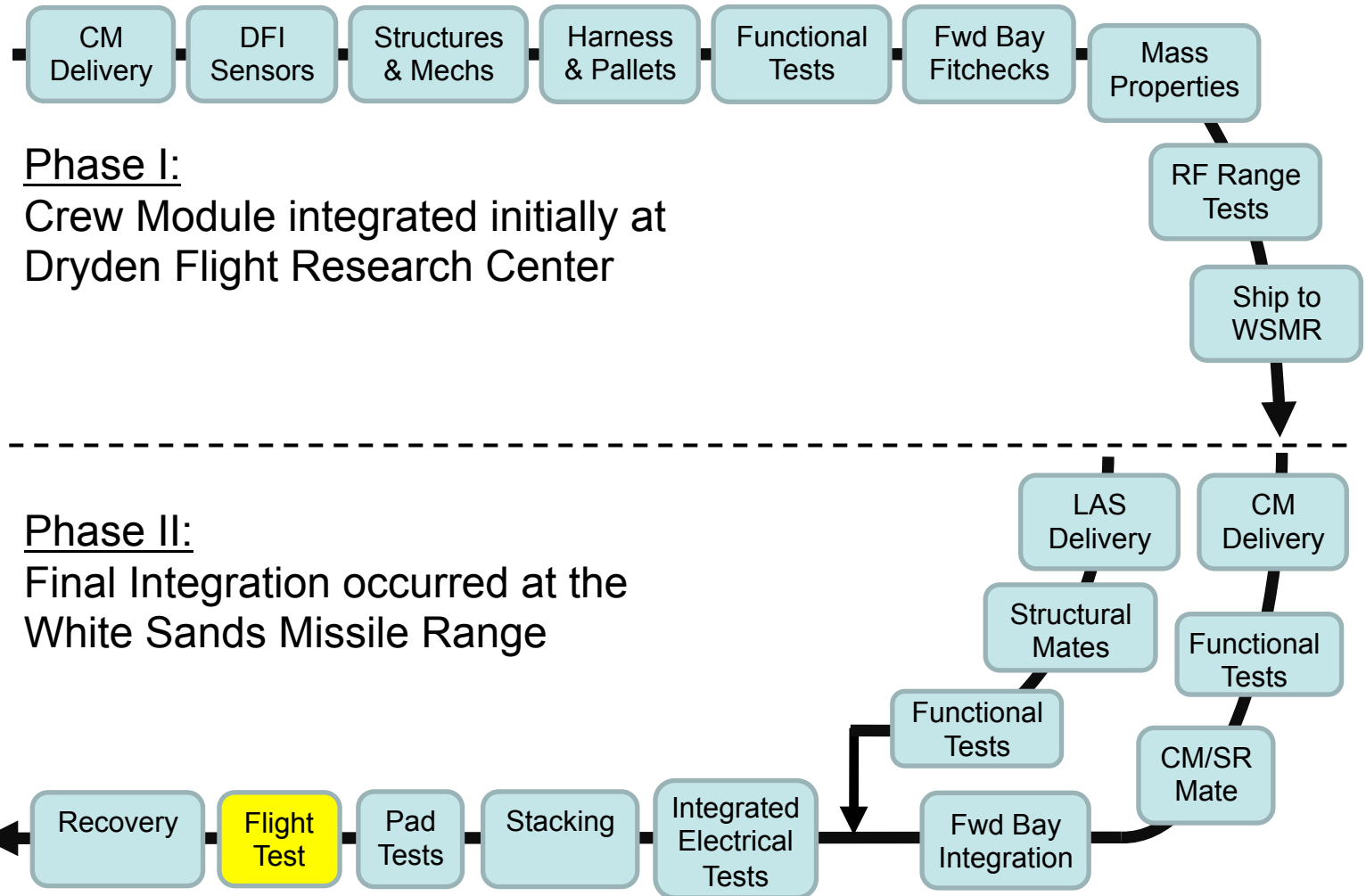
***Operations Support Trailer***



# ***INTEGRATION AND TESTING***



# *Test Vehicle assembly, integration, and testing occurred in two phases*







# ***Crew Module was outfitted with sensors, avionics, and mechanisms at NASA Dryden***



***CM Arrival via C-17***



***Painted w/Test Pattern***



***Avionics Pallets and  
Harnesses Installed***



***Installing Sensors and Cameras***



***Crew Module being integrated in Shuttle Hangar at  
NASA Dryden Flight Research Center***



***CM Functional and RF Tests***



***Mass Properties Tests***



## ***Launch Abort System was assembled and checked at the launch site***



***Motor Roll Transfer  
onto integration trailer***



***Adapter Cone  
placement***



***Structural Mates***



***LAS Functional Tests***



***LAS being prepared in the Final Integration and Test Facility***



***LAS Ready for Roll-Out***

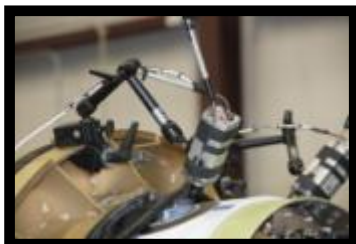




## ***Integrated electrical tests verified Crew Module and Launch Abort System interfaces***



***Crew Module Forward  
Bay Integration***



***Setting up cameras to  
monitor Phasing Test***



***Attitude Control  
Motor Functional  
Test***



***Crew Module / Launch Abort System Soft Mate Testing***



## ***Pad Operations included stacking the Test Vehicle and performing final tests and launch preparations***



***Test Vehicle stacked onto Launch Pad***



***Crew Module being stacked onto Launch Pad***



***Launch Abort System being stacked onto Crew Module***



***Measuring Stack Straightness with Laser Scans***



***Thermal Cover installed*** 20



# ***FLIGHT OPERATIONS PLANNING AND EXECUTION***

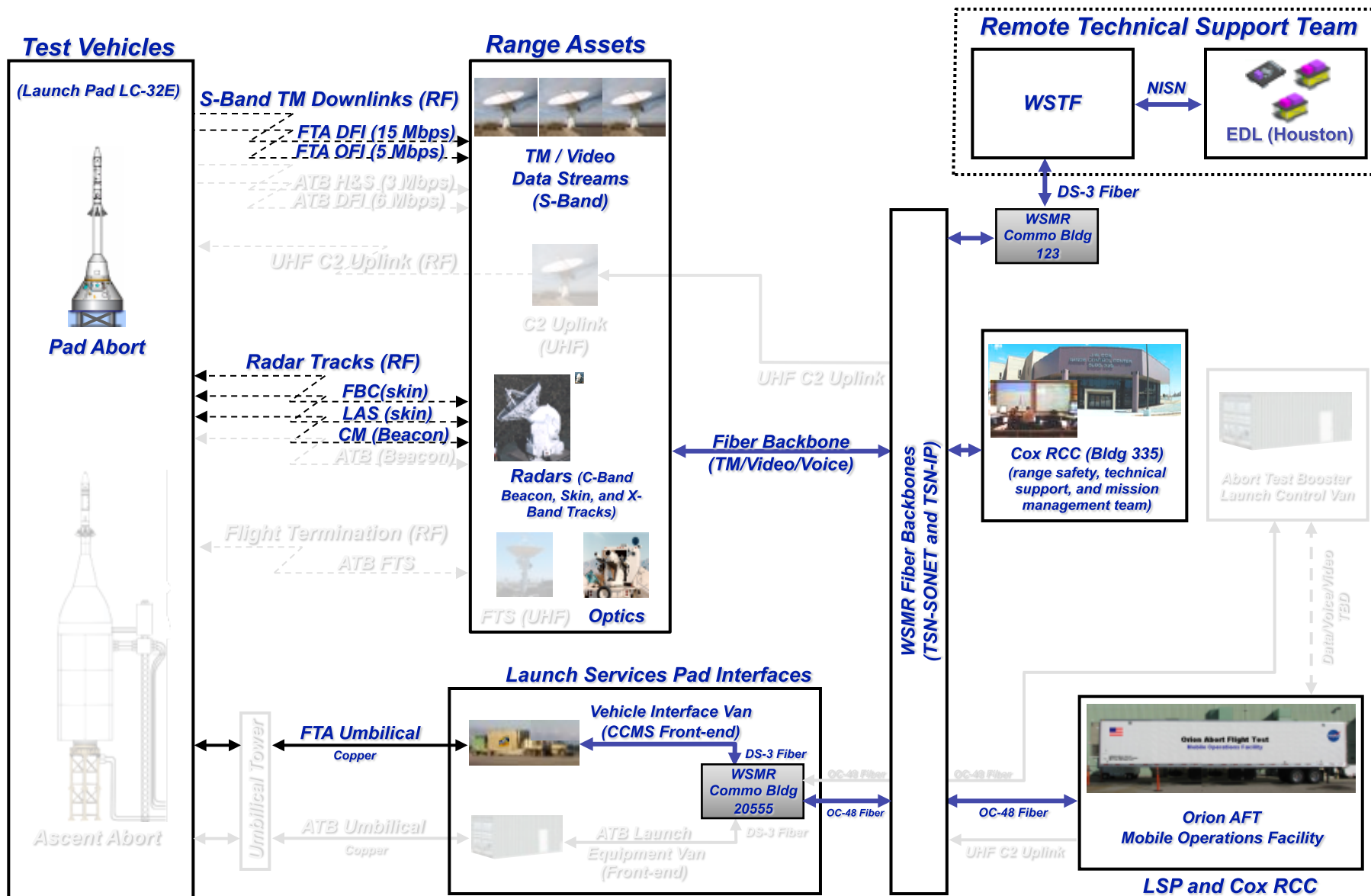


## ***Flight Ops Challenges***

- Mobile Control Room Architecture
- Launch Team Training
- Range Assets



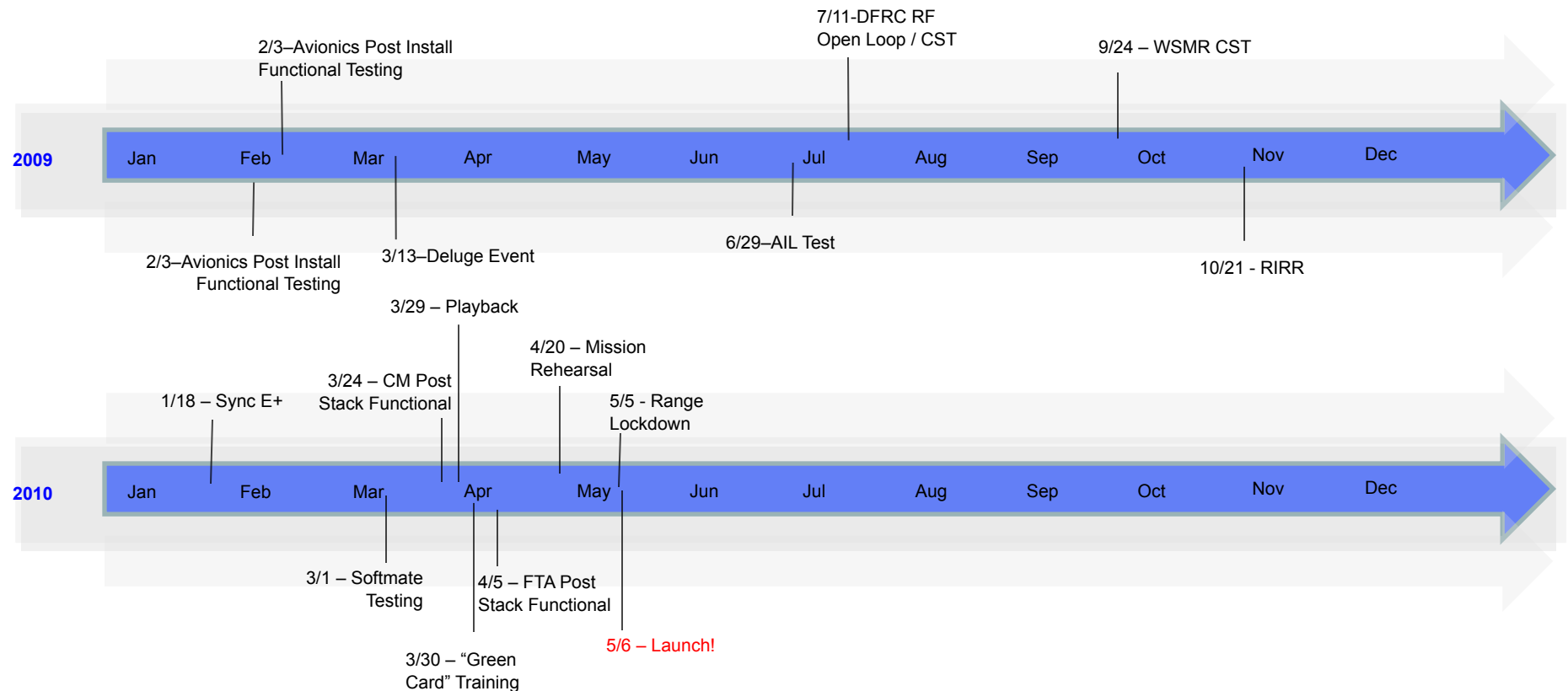
# Mobile Operations - WSMR Mission Architecture







# Launch Team Training

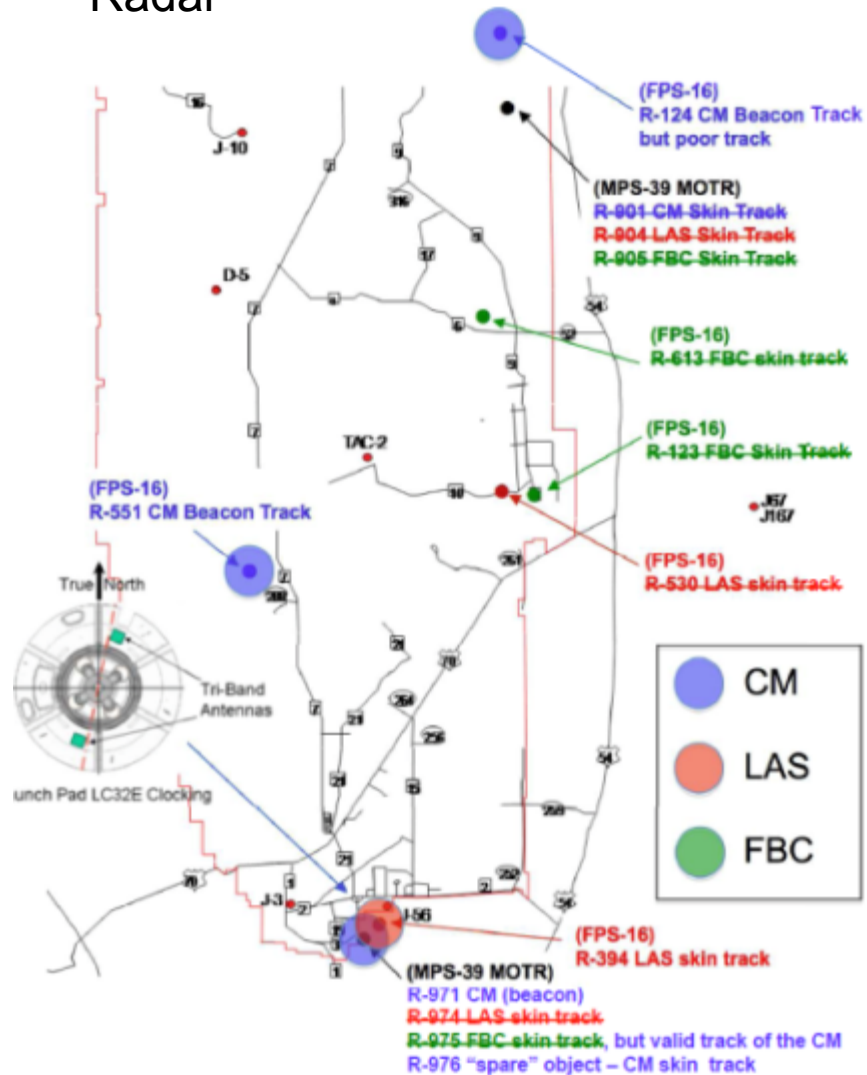


- In addition to Training on timeline in the 1.5 months prior to launch
  - 3 Table Top Reviews (TTR) with the entire team
  - 2 Emergency/Contingency Procedure simulation trainings
  - 2 PAO rehearsals
  - 3 Test Specific TTR's and Emergency procedure planning
  - Mishap Response Planning
  - Recovery Ops dry-run
- Incorporation of training around launch timeframe is difficult and required full commitment from the entire project

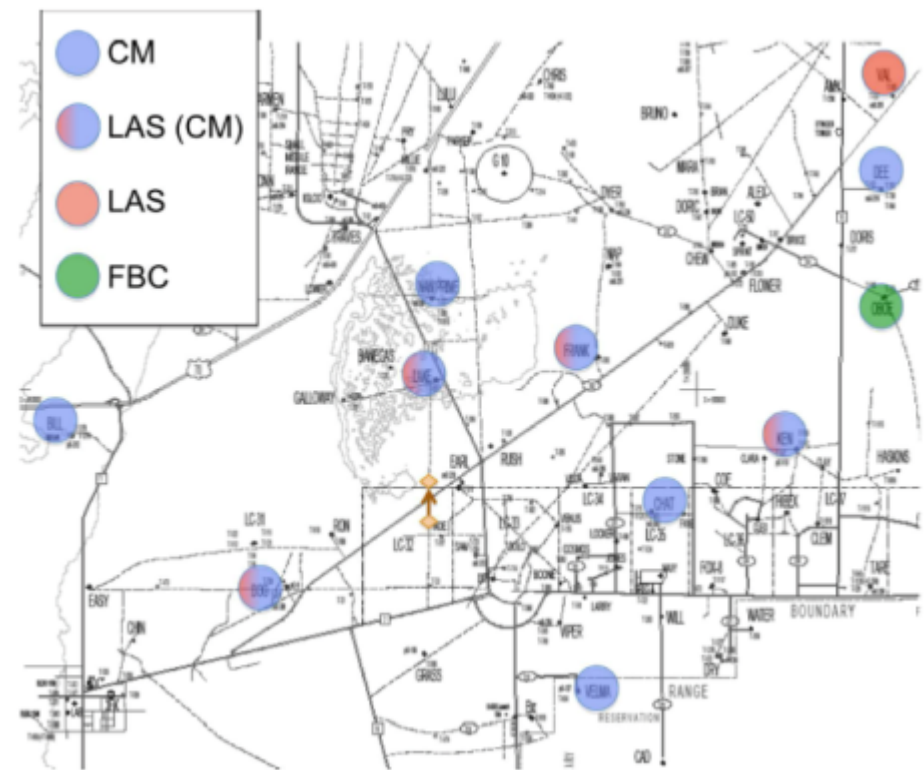




# Radar



## Camera's

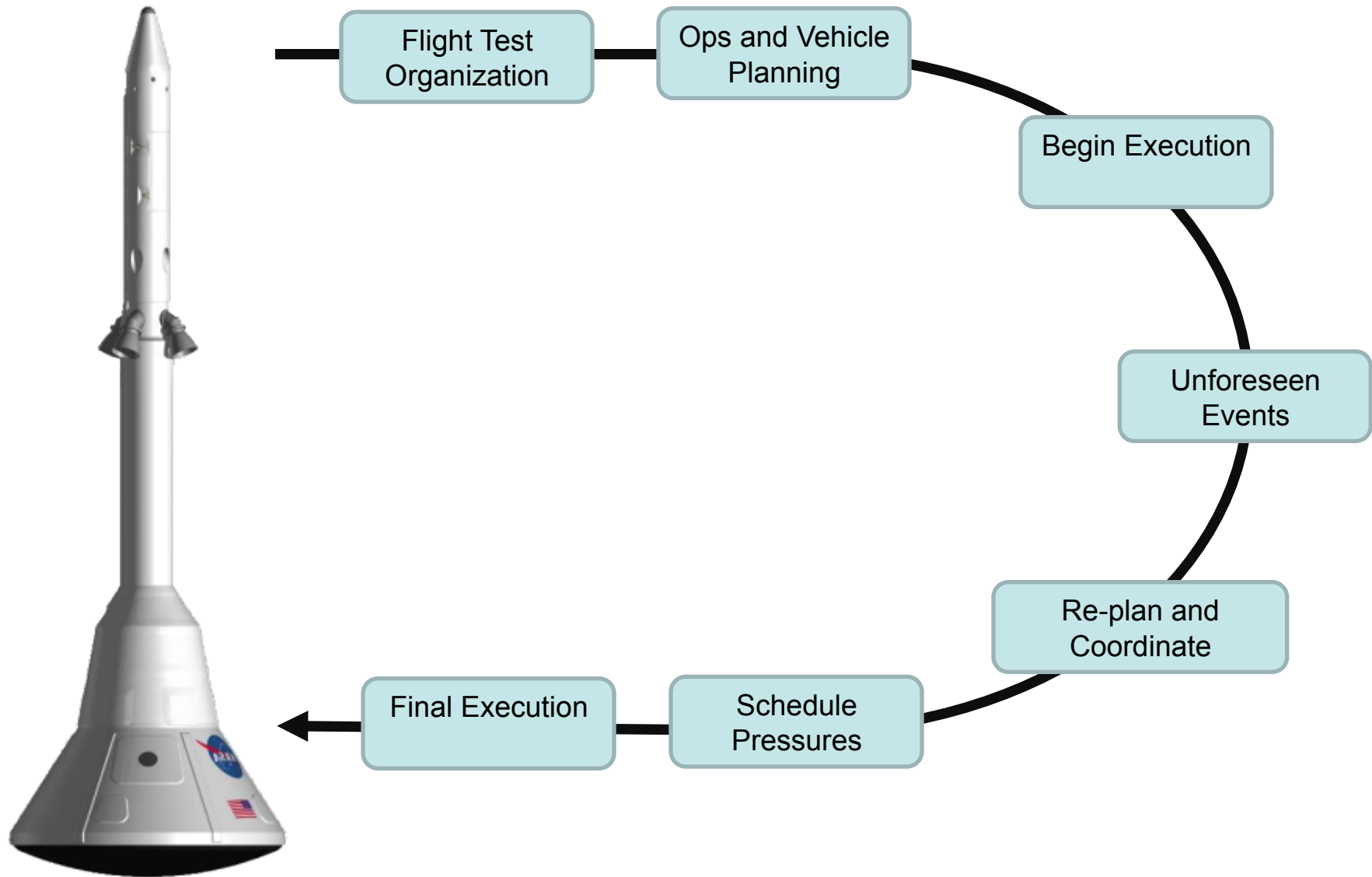




# ***A FEW KEY CHALLENGES AND SUCCESSES***



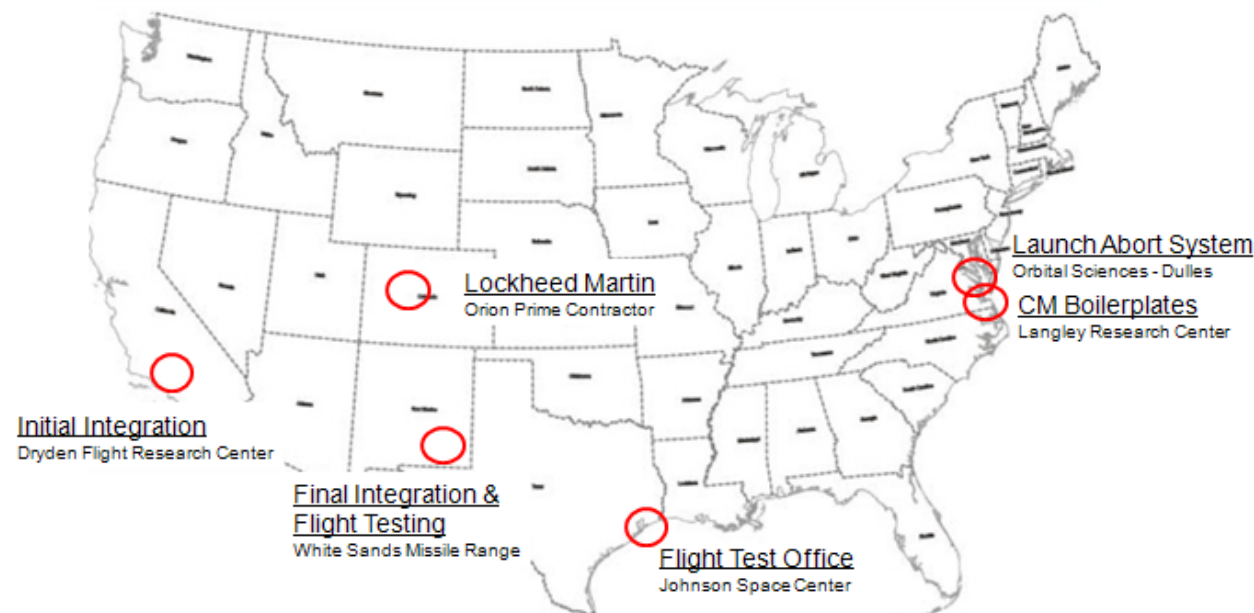
## ***The Project overcame many challenges***





## Coordination and Resources

- Coordination and planning of resources was difficult due to a constantly changing schedule
- Keeping all parties involved at all times during integration phases allowed for extra support during surges – A representative for people at the test location proved extremely useful
- Running 2 shifts the final month prior to launch included engineering and technician support from all project locations.
- Daily Ops tag-up helped improved situational awareness in all time zones
- Utilization of the entire teams knowledge and skills was essential in meeting the aggressive launch date that was planned 2 months prior





## ***Pathfinder and Risk Reduction Operations***

- Conducted for all operations that involved pyrotechnics, including integration and lifts. (In plan)
- Fit checks (opportunity based)
- Conducted (as time allowed) for Day-of-Flight Operations and other key issues such as integration with WSMR (opportunity based)

### Challenges:

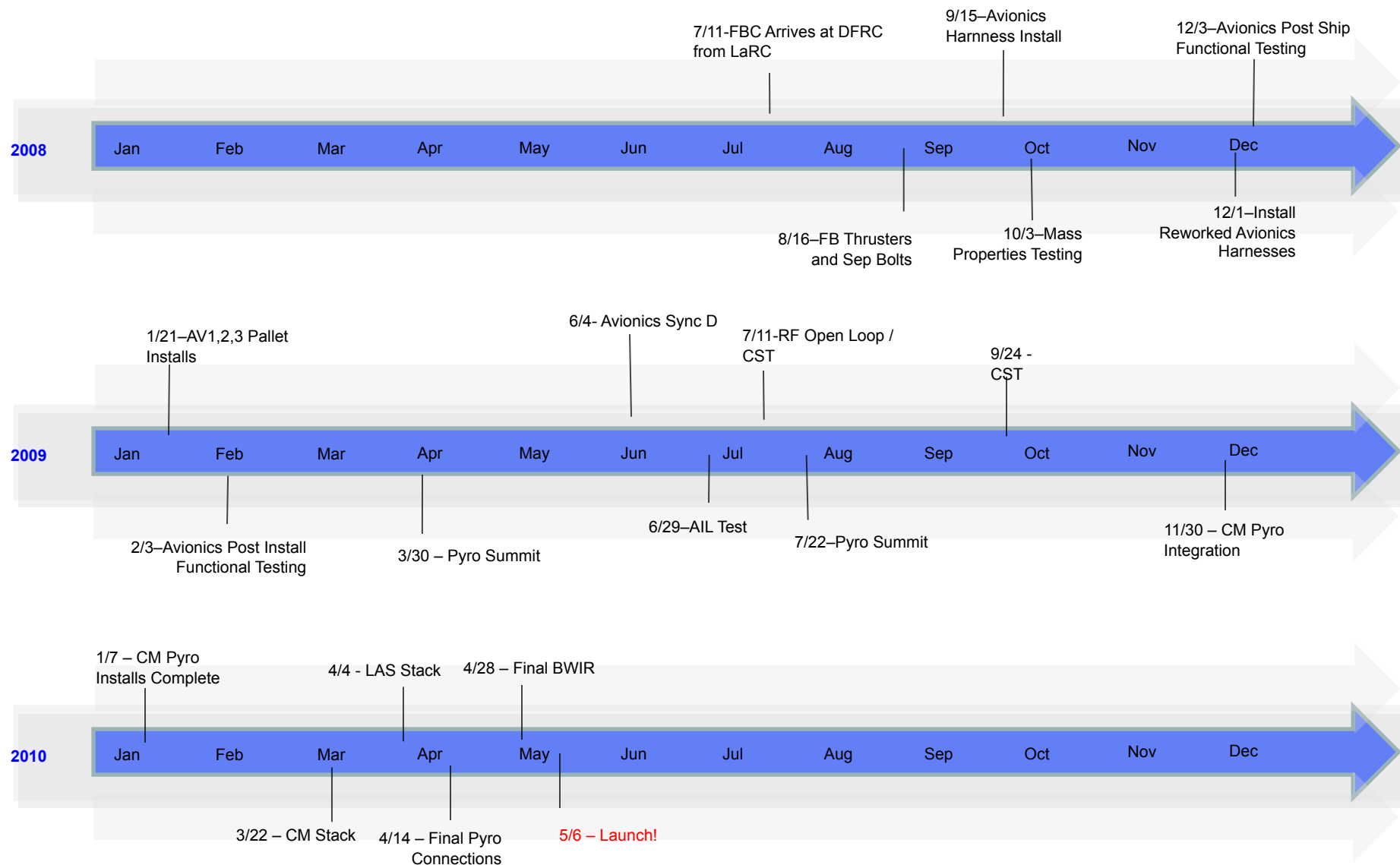
- Required significant planning and dedication by the entire team.
- Scheduling around other required activities was difficult
- Timing of operations not ideal relative to other project activities such as acceptance testing
- Developing SOP's

### Successes

- Personnel safety maximized for all operations
- Procedures released on time and conducted with minimal red-lines.
- Risk Reduction – changes and issues were identified early
- Confidence in operations allowed them to easily be performed on night shift
- Finished operations ahead of schedule!!!



# Pathfinder Ops - Pyrotechnics Integration Timeline





## Recovery

1. Receive Post-Landing Assessment from MOF (Scorecard)
2. Deploy to LZ staging Point
3. UXB sweep for UXO
4. Assess hazards preventing safe approach
5. Approach and Safe
6. Repeat 4&5 according to Hazard Analysis
7. Transport to LC32 or other destination

NOTE: Photo document entire process







## *Questions?*



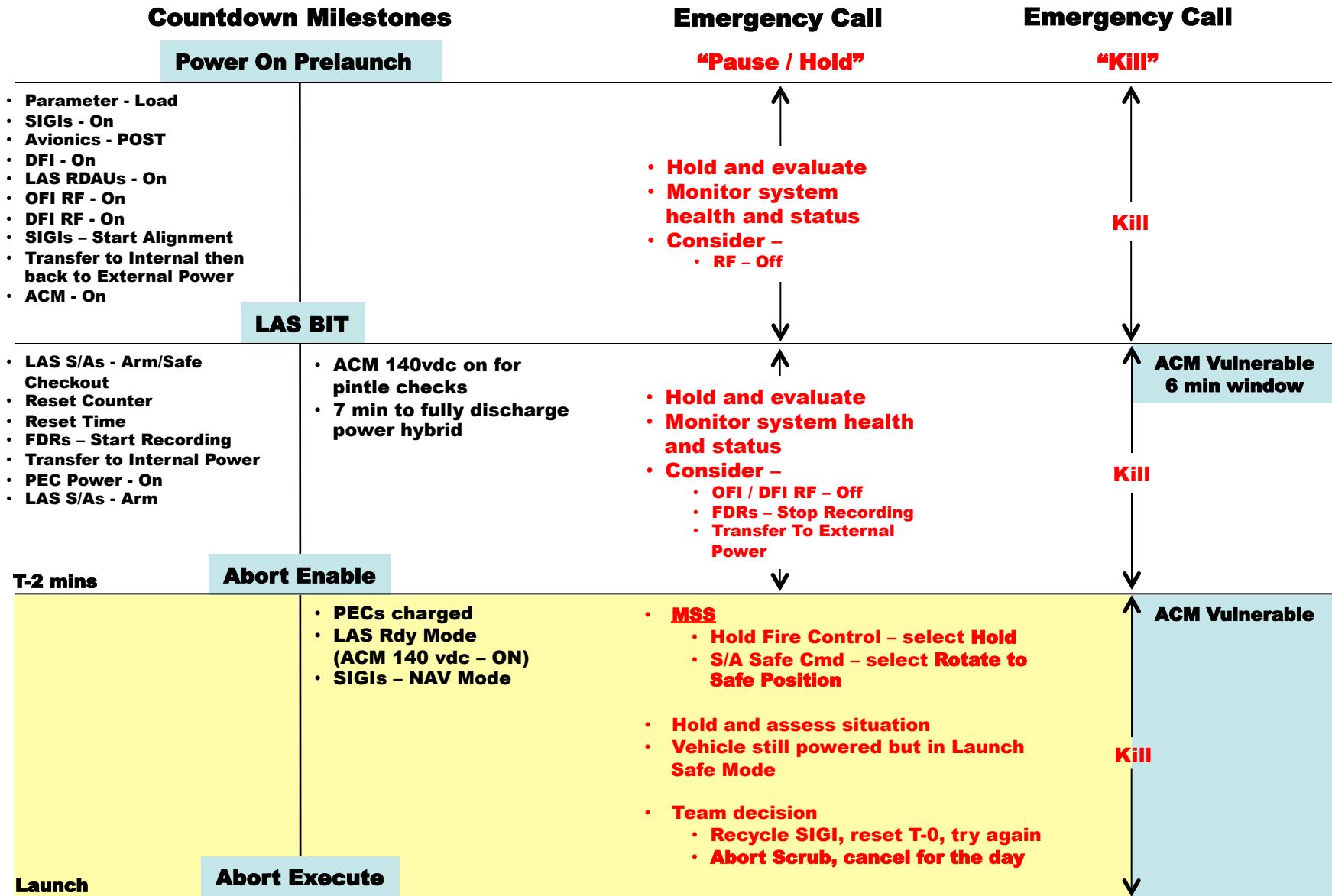




***BACK-UP***



# Off Nominal Procedures Overview





# PA-1 Communications Plan

## Version 4-10-10

